ME-86-01

The Chloride Content of Concrete Bridge Decks in Ontario with Particular Reference to Deck Soffits

Ontario
Ministry of Transportation and Communications
Research and Development Branch

ME-86-01

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R.S. Reel
Evaluation Engineer

D.G. Manning
Principal Research Engineer

Published by
The Research and Development Branch
Ontario Ministry of Transportation and Communications
Honourable Ed Fulton, Minister
D.G. Hobbs, Deputy Minister

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For additional copies, contact:
The Editor, Technical Publications
Room 320, Central Building
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8

Telephone: (416) 248-7226
CNCP Electronic Mail: 21:MIN006

May 1986

Technical Report Documentation Page

MTC Report Number ME-86-01	ISBN Number:	Other Document Number:	Date: May 1986

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Authors: R.S. Reel, Evaluation Engineer, Structural Office
D.G. Manning, Principal Research Officer, R&D Branch

Published by:

The Research & Development Branch
Ontario Ministry of Transportation and Communications

Client Group:

Participating Agencies:

The Structural Office
Highway Engineering Division

Abstract:
This report describes the investigation of the chloride content of bridge decks in service. Twenty-seven decks were sampled, and were chosen to be representative of four variables: type of deck, age, surface type, and exposure conditions with respect to surface run-off and salt spray from traffic. The chloride content was measured at several horizons and the amount of chloride ion which had penetrated the concrete from the deck top and soffit to the currently specified levels of the reinforcement was calculated.

In most cases, the chloride contamination in deck soffits was below the threshold value for corrosion. There was no relationship between chloride contamination and deck type, age, location, or traffic volume. Where the chloride contamination exceeded the corrosion threshold value, it was generally the result of surface run-off through open joints or railings or, occasionally, defects in construction.

Recommendations are made to minimize chloride-induced corrosion in new designs, including details for the use of epoxy-coated reinforcement, and in existing bridges.

Key Words: bridge decks, corrosion, chlorides, durability, maintenance

Comments:

Distribution: Structural Management Committee, maintenance engineers

Copyright Status: Crown copyright

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1. INTRODUCTION

A study of the chloride levels in concrete bridge deck soffits was initiated in 1983 for the Committee on the Technology for Structure Durability. The purpose of the study was to determine the effects of salt spray from vehicular traffic and salt run-off on deck soffits and make recommendations for appropriate corrosion protection treatment.

2. SCOPE

Twenty-seven bridges were selected for the study to represent the following conditions:

A) Types of Decks

Approximately equal numbers of the following types of decks which represent the majority of the concrete decks in the province:

- thin slabs on beams or girders,
- solid thick slabs,
- thick slabs with round voids,
- thick slabs with rectangular or trapezoidal voids.

B) Age of Decks

Approximately equal numbers of decks from the following age groups to represent the effects of age:

- 1930 to 1944
- 1945 to 1960
- 1961 to 1975

C) Type of Surface

The following types of deck surface treatments which represent the types of surface treatments used since 1930:

- exposed concrete decks,
- asphalt covered decks,
- waterproofed and asphalt covered decks.

D) Location

For logistical reasons, the bridges included in the survey were limited to Districts 4,6 and 7. However, the decks were representative of bridges located in Southern Ontario.

E) Exposure Conditions

The exposure conditions against salt spray from vehicular traffic under the decks varied from no salt spray in the case of decks over streams to very heavy salt spray on decks over freeways.

The exposure conditions against surface run-off varied from no run-off due to the presence of a barrier wall to unrestricted run-off in the case of open type railings or open longitudinal joints.

The identification and details of construction of the bridges included in the survey are given in Tables 1A to 1C. The traffic volumes over and under the bridges are included to give an indication of the quantity of salt usage and the amount of vehicle spray. None of the bridges located in grade separations had an unusually high clearance.

3. FIELD INVESTIGATION

The field investigation was carried out in October and November of 1983. It consisted of:

- visual inspection of the decks,
- photographs of the deck soffits,
- full depth coring of the decks.

The cores were either 50 or 100 mm in diameter and were located to represent typical conditions of the deck such as:

- first driving lane, shoulder, curb or sidewalk,
- between beams, or through voids.

It was the original intention to take three cores per deck. However, due to the limited time for traffic protection and the difficulty of obtaining full depth cores at several sites, the numbers of cores actually removed were as follows:

- 3 cores each from 19 decks,
- 2 cores each from 5 decks,
- 1 core each from 3 decks.

The location of the cores in each structure are given in Tables 2A to 2C.

4. CHEMICAL ANALYSIS

The chloride ion content of both the top and the soffit of decks was determined by slicing the cores into 10 mm slices and testing alternate slices in accordance with Ministry test method LS 411: Method of Testing for Water Soluble Chloride Ion in Concrete. The test procedure is substantially the same as the method described in Report FHWA-RD-77-85(1). The results of these tests are shown in Tables 3A to 3F.

5. ANALYSIS OF CHLORIDE RESULTS

The percentage of soluble chloride for each core was plotted on graph paper and the chloride content determined at the minimum level of reinforcing steel specified in the current edition of the Ontario Highway Bridge Design Code. In other words, the values are an approximation of the maximum chloride content which would be expected at the level of the steel in bridges built to current specification requirements for cover and at the same locations as the bridges included in the survey. This assumption is a simplification because it neglects the effect of such factors as the quality of the concrete and increases in traffic volumes. However, the procedure is a valid first level of approximation.

The specified level of reinforcing steel used was as follows and is according to OHBDC (2).

- thin slabs, top - 50 mm
- thin slabs, bottom - 30 mm
- solid and voided thick slabs, top - 50 mm
- solid and voided thick slabs, bottom - 40 mm.

The background chloride ion content was also read from the graphs for each core and subtracted from that read at the specified level of reinforcing, to give the quantity of chloride ions which would have penetrated the concrete to the reinforcement.

The chloride threshold value for corrosion is generally accepted to be 0.15% soluble chloride ion by mass of cement. For a typical bridge concrete having a cement content of 390 kg/m^3 and a mass density of 2320 kg/m^3, this corresponds to a threshold value of 0.025% by mass of concrete. For the purposes of this analysis, a more conservative figure of 0.02% soluble chloride content by mass of concrete was used as the corrosion threshold value.

5.1 Chloride Contents Below the Threshold Value in Deck Soffits

The chloride contents are plotted against construction date in Figures 1(a) to 1(c) for the tops and soffits of decks by the types of decks. They are also plotted against traffic volumes in Figures 2(a) and 2(b).

It can be seen from Table 3 and from Figures 1 and 2 that the amount of soluble chloride in the soffits of decks is, in most cases, below the threshold value for corrosion.

The four decks where the amount is above this value are discussed in Section 5.2.

It is also apparent that the percentage of chloride ion in soffits of decks is not related to:

- the type of decks,
- the age of the bridge,
- the area of the Province where the bridge is located,
- the amount of salt spray as expected from the vehicular traffic going under the bridges for deck soffits or going over the bridges for deck tops.

5.2 Chloride Contents Above the Threshold Value in Deck Soffits

The four deck soffits that had soluble chloride values above the threshold value 0.02% by mass of concrete are discussed below.

- Site 18-13 - 40 Mile Creek/QEW

  This is a rigid frame with 900 mm curbs and open type steel railing built in 1938. The bridge carries the QEW over the 40 Mile Creek. A single core was taken through the curb.

The high soluble chloride value is a result of surface run-off (containing salt) flowing over the side of the curb through the open railings and travelling across the soffit.

- Site 37-964 - Martingrove/Hwy 409

There are twin post-tensioned slab bridges built in 1973 at this site. The median consists of 900 mm curbs separated by a 50 mm open longitudinal joint. The cores were taken at a distance of 2.5 m from the open longitudinal joint.

The high soluble chloride values are a result of salt water flowing through the open longitudinal joint and across the soffit. Due to the superelevation on this deck and the inclined shape of the soffit, the water can flow across the soffit for almost the full width of the soffit. The 20 mm drip check in the soffit is totally ineffective, as shown in Figure 3. The figure also shows the deterioration which has occurred in the concrete adjacent to the longitudinal joint.

It is significant to compare this site with Site 37-967, Highway 27, Bridge 5/Hwy 409. These two bridges are on the same highway within 1 km of each other. They have similar traffic counts under and over the bridges. They were built within one year of each other. The only difference is that the cores on Site 37-967 were taken near the east sidewalk. A concrete parapet wall effectively prevents the salt water from falling over the side of the bridge, except at the construction joints in the parapet wall. The soluble chloride values in the soffit of Site 37-967 are negligible compared to those in Site 37-964.

- Site 34-32 - Portage Road/Hwy 420

This is a two span rigid frame with sidewalks and open type railings built in 1939. In 1977, extensive freeze-thaw damage to the top and bottom of the deck in both spans was repaired. The repairs consisted of:

- removal of deteriorated concrete from the top and soffit of the deck,
- repair of deck top with portland cement concrete, waterproofing, and paving,
- repair of deteriorated parts of deck soffit with epoxy concrete,
- replacement of the open type railings with concrete parapet walls.

The high chloride value in one of the cores in the deck soffit can be explained by the fact that it was in an area of the soffit that had not been repaired. The high value is due to the salt water flowing over the side of the deck and across the soffit or due to the salt water seeping through the deteriorated deck before the repairs were made, or a combination of both.

The low values in the deck top are due to the fact that the cores went through the repairs carried out in 1977.

- Site 21-172 - Newcastle UP/Hwys 2 & 35
  This is a rigid frame built in 1955 and has curbs and open steel handrails. The deck was cast in four sections with longitudinal construction joints.

  The one core that has high chloride value was located near a longitudinal construction joint that had been leaking.

5.3 Chloride Contents in Deck Tops

The chloride contents in deck tops are typical of values obtained from other core results over the last few years. The rehabilitation methods for deck tops are well known and are adequately covered in Reference 3. Therefore, further analysis of the deck top results has not been carried out as part of this report.

6. RECOMMENDATIONS FOR NEW DESIGNS

6.1 Designs With Concrete Parapet Walls or Barrier Walls

- Epoxy coated bars as in Clause 12.1.2 of The Structural Manual (4).
- Drip detail as shown in Figure 4.

  The recommended drip detail was compared with a half-round drip detail under laboratory conditions and found to be superior.

6.2 Designs With Open Type Railings

- Epoxy coated bars as shown in Figure 5.
- 2 mm extra thickness on exterior steel girders, as shown in Figure 5.
- Drip detail as shown in Figure 4.

  A cost comparison between the 2 mm extra thickness and periodic applications of a protective coating over a 50 year period showed that the extra thickness was considerably less expensive.

6.3 Designs With Sealed or Unsealed Longitudinal Joints

- Epoxy coated bars as shown in Figure 4.
- Seal all longitudinal joints.

6.4 Designs With Sealed or Unsealed Transverse Joints

- Epoxy coated bars as shown in Figure 6.
- An approved coating on the ends of steel girders, as shown in Figure 6.
- Seal all transverse joints.

6.5 Designs With Deck Drains

- Structure components to be protected where subject to discharge from deck drains (cases to be treated individually).

7. RECOMMENDATIONS FOR EXISTING BRIDGES

As part of the rehabilitation of bridge decks, the following recommendations should be carried out wherever practical:

- seal longitudinal joints,
- seal transverse joints,
- replace open type railings with concrete parapet walls or barrier walls.

REFERENCES

1. Clear, K.C., and Harrigan, E.T., "Sampling and Testing for Chloride Ion in Concrete", Rep. No. FHWA-RD-77-85, FHWA (1977).

2. Ontario Highway Bridge Design Code, 1983, Ministry of Transportation and Communications, Ontario.

3. Bridge Deck Rehabilitation Manual, Ministry of Transportation and Communications, November 1983.

4. Structural Manual, Ministry of Transportation and Communications, 1986.

ACKNOWLEDGEMENTS

This project was carried out jointly by the staff from the following offices of the Ministry:

- Materials and Engineering Systems Office
- Structural Office
- Engineering Materials Office

and also

The Committee On The Technology For Structural Durability.

TABLE 1 - LIST OF DECKS CORED

A - Thin Slab Decks on Beams

MTC Site No.	Bridge Name	Hwy.	Dist.	Const. Date	Crossing	AADT Under	AADT Over	Wearing Surface
10-52	County Rd 22/401	401	4	1959	Road	35,000	250	Asphalt, no water-proofing
18-170	Glendale Ave/406	406	4	1963	Road	5,000	24,000	Concrete
21-227	Hope Twp Br 8	401	7	1959	Road	22,000	200	Waterproofed and repaired in 1971
22-149	Lynde Cr/12	12	6	1958	Water	--	4,000	Asphalt, no water-proofing
24-131	Toronto Twp Br 11/401	401	6	1958	Road	69,000	200	Asphalt, no water-proofing
32-78	Emery Cr/36	36	7	1937	Water	--	2,000	Waterproofed and repaired in 1979
37-5	Pefferlaw Brook/48	48	6	1968	Water	--	5,000	Waterproofed and paved in 1973
37-212	Birchmount Rd/401	401	6	1969	Road	190,000	20,000	Concrete
37-218	Markham Rd/401	401	6	1972	Road	130,000	10,000	Concrete

TABLE 1 (cont) - LIST OF DECKS CORED

B - Solid Thick Slabs

MTC Site No.	Bridge Name	Hwy.	Dist.	Const. Date	Crossing	AADT Under	AADT Over	Wearing Surface
10-19	Nassagaweya Twp/401	401	4	1959	Road	35,000	250	Asphalt, no water-proofing
18-13	40 Mile Creek/QEW	QEW	4	1938	Water	--	36,000	Waterproofed and paved 1969
21-172	Newcastle U'P/Hwy 2/35	2/35	7	1955	Road	5,300	9,200	Asphalt, no water-proofing
21-191	Wilmot Creek/401	401	7	1958	Water	--	20,000	Waterproofed and paved 1975
22-25	Beaverton Rv/12	12	6	1965	Water	--	5,000	Asphalt, no water-proofing
22-121	Harwood Ave SB/401	401	6	1940	Road	63,000	15,360	Waterproofed and paved 1977, 1982
22-151	Brock St/401	401	6	1941	Road	63,000	6,000	Waterproofed and paved 1975
34-32	Portage Rd/420	420	4	1939	Road	18,000	4,000	Concrete overlay, waterproofed and paved 1977
37-33	Hwy 9/400	9/400	6	1947	Road	32,000	8,000	Waterproofed and paved 1971
37-341	Yonge St Br 3/401	401	6	1967	Road	25,000	220,000	Concrete
37-967	Hwy 27 Br 5/409	27/409	6	1974	Road	43,000	25,000	Waterproofed and paved 1974

TABLE 1 (cont) - LIST OF DECKS CORED

C - Thick Slabs With Voids

MTC Site No.	Bridge Name	Hwy.	Dist.	Const. Date	Crossing	AADT Under	AADT Over	Wearing Surface
	- Round Voids							
18-179	County Rd 22/NS Rd	NS Rd	4	1966	Road	500	250	Cathodic protection 1981
18-193	Br 9 - Ramp K over St. David's Rd	406	4	1968	Road	2,000	23,000	Concrete
21-338	Hwy 28 O'P	28/115	7	1966	Road	7,600	5,000	Concrete
37-964	Martingrove/409	409	6	1973	Road	43,000	25,000	Waterproofed and paved 1973
	- Rectangular Void							
10-149	Service Rd/QEW	QEW	4	1959	Road	81,000	2,000	Waterproofed and repaved 1972
36-29	Chedoke Exp Ramp	403	4	1961	Road	45,000	26,000	Waterproofed and repaved 1982
37-93	King's Sideroad/400	400	6	1950	Road	41,000	200	Waterproofed and repaved 1970

TABLE 2 - CORE LOCATIONS

A - Thin Slab Decks on Beams

MTC Site No.	Bridge Name	Location On The Bridge	Location Below The Bridge
10-52	County Rd 22/401	- 600 mm from curb face - between first and second beams	- over shoulder and first lane
18-170	Glendale Ave/406	- 150 mm from curb face - between first and second girders	- over shoulder and first lane
21-227	Hope Twp Br 8	- 1 m from curb face - between first and second girders	- over shoulder and first lane
22-149	Lynde Cr/Hwy 12	- 300 mm from curb face - between first and second beams	- over stream
24-131	Toronto Twp Br 11/401	- 1.6 m from curb face - between first and second beams	- over first lane
32-78	Emery Cr/36	- 175 mm from face of sidewalk - between first and second beams	- over stream
37-5	Pefferlaw Brook/48	- 300 mm from face of sidewalk - between first and second beams	- over stream
37-212	Birchmount Rd/401	- 1.6 m from curb - between first and second beams	- over shoulder and first lane
37-218	Markham Rd/401	- 2.7 m from centre line of median - between beams	- over shoulder and passing lane

TABLE 2 (cont) - CORE LOCATIONS

B - Solid Thick Slabs

MTC Site No.	Bridge Name	Location On The Bridge	Location Below The Bridge
10-19	Nassagaweya Twp/401	- 300 mm from curb face	- over shoulder and first lane
18-13	40 Mile Creek/QEW	- through north curb	- over stream
21-172	Newcastle U'P/Hwy 2/35	- perpendicular to curb - through shoulder and first lane	- over shoulder
21-191	Wilmot Creek/401	- 300 mm from curb face	- over stream
22-25	Beaverton Rv/12	- through curb	- over stream
22-121	Harwood Ave SB/401	- 700 mm from parapet wall	- over lane
22-151	Brock St/401	- 300 mm from sidewalk face	- over lane
34-32	Portage Rd/420	- 300 mm from curb face	- over lane
37-33	Hwy 9/400	- 300 mm from curb face	- over shoulder and first lane
37-341	Yonge St Br 3/401	- perpendicular to curb - through shoulder and first lane	- over lane
37-967	Hwy 27 Br 5/409	- 150 mm from sidewalk face	- over shoulder and first lane

TABLE 2 (cont) - CORE LOCATIONS

C - Thick Slabs With Voids

MTC Site No.	Bridge Name	Location On The Bridge	Location Below The Bridge
	- Round Voids		
18-179	County Rd 22/NS Rd	- 150 mm from curb lane - partly through void, partly through solid section	- over shoulder and first lane
18-193	Br 9 - Ramp K over St. david's Rd	- 2 m from curb face - through void	- over shoulder
21-338	Hwy 28 O'P	- 1.63 m from curb face - through void	
37-964	Martingrove/409	- 2.4 m from centre line of median - through void	- over passing lane
	- Rectangular Void		
10-149	Service Rd/QEW	- 300 mm from curb face - through void	- over median shoulder
36-29	Chedoke Exp Ramp	- 600 mm from curb face - through void	- over shoulder and first lane
37-93	King's Sideroad/400	- 600 mm from curb face - through void	- over shoulder and first lane

TABLE 3 - CHLORIDE CONTENT BY MASS OF CONCRETE

A - Thin Slab Decks on Beams - Top

Site No.	Sample	% Soluble Cl^- at Level of Steel (50 mm) (A)	% Background Soluble Cl^- (B)	Soluble Cl^- Contamination at Level of Steel (50 mm) (A-B)
10-52	A1	.0790	.0340	.0450
	B1	.0900	.0340	.0560
	C1	.1100	.0340	.0760
18-170	A1	.0120	.0110	.0010
	B1	.0144	.0110	.0034
	C1	.0168	.0110	.0058
21-227	A1	.0080	.0050	.0030
	B1	.0090	.0050	.0040
	C1	.0085	.0050	.0035
22-149	A1 + A2	.0875	.0126	.0649
	B1 + B2	.0695	.0126	.0469
24-131	A1	.1850	.0300	.1550
	B1	.4000	.0300	.3700
	C1	.1600	.0300	.1300
32-78	A1	.0100	.0020	.0080
	B1	.0070	.0020	.0050
	C1	.0030	.0020	.0010
37-5	A1	.0080	.0040	.0040
	B1 + B2	.0120	.0040	.0080
	C1	.0150	.0040	.0110
37-212	A1	.0300	.0130	.0170
	B1	.0200	.0130	.0070
	C1	.0200	.0130	.0070
37-218	A1	.1250	.0236	.1014
	B1	.0250	.0236	.0014
	C1	.0350	.0236	.0114

TABLE 3 (cont) - CHLORIDE CONTENT BY MASS OF CONCRETE

B - Thin Slab Decks on Beams - Soffit

Site No.	Sample	% Soluble Cl^- at Level of Steel (50 mm) (A)	% Background Soluble Cl^- (B)	Soluble Cl^- Contamination at Level of Steel (50 mm) (A-B)
10-52	A1	.0415	.0340	.0075
	B1	.0355	.0340	.0015
	C1	.0345	.0340	.0005
18-170	A1	.0170	.0110	.0060
	B1	.0143	.0110	.0033
	C1	.0157	.0110	.0047
21-227	A1	.0120	.0050	.0070
	B1	.0165	.0050	.0115
	C1	.0120	.0050	.0070
22-149	A1 + A2	.0126	.0126	.0000
	B1 + B2	.0160	.0126	.0034
24-131	A1	.0338	.0300	.0038
	B1	.0406	.0300	.0106
	C1	.0310	.0300	.0010
32-78	A1	.0045	.0020	.0025
	B1	.0047	.0020	.0027
	C1	.0047	.0020	.0027
37-5	A1	.0066	.0040	.0026
	B1 + B2	.0055	.0040	.0015
	C1	.0056	.0040	.0016
37-212	A1	.0176	.0130	.0046
	B1	.0142	.0130	.0012
	C1	.0169	.0130	.0039
37-218	A1	.0305	.0236	.0069
	B1	.0254	.0236	.0018
	C1	.0236	.0236	.0000

TABLE 3 (cont) - CHLORIDE CONTENT BY MASS OF CONCRETE

C - Solid Thick Slab Decks - Top

Site No.	Sample	% Soluble Cl^- at Level of Steel (50 mm) (A)	% Background Soluble Cl^- (B)	Soluble Cl^- Contamination at Level of Steel (50 mm) (A-B)
10-19	A1	.0425	.0270	.0155
	B1 + B2	.0425	.0270	.0155
	C1	.0550	.0270	.0280
18-13	A1	.0075	.0075	.0000
21-172	A1	.0100	.0100	.0000
	B1	.0230	.0100	.0130
	C1	.0205	.0100	.0105
21-191	A1	.0495	.0130	.0365
	B1 +B2	.0650	.0130	.0520
22-25	A1	.0060	.0020	.0040
	B1	.0070	.0020	.0050
	C1	.0065	.0020	.0045
22-121	B1 +B2	.0110	.0090	.0020
	C1	.0090	.0090	.0000
22-151	A1	.0290	.0040	.0250
	C1	.0050	.0040	.0010
34-32	A1	.0220	.0150	.0070
	B1	.0420	.0150	.0270
	C1	.0490	.0150	.0340
37-33	A1	.0490	.0330	.0160
	B1	.0350	.0330	.0020
	C1	.0600	.0330	.0270
37-341	A1	.0200	.0150	.0050
	B1	.0750	.0150	.0600
	C1	.1100	.0150	.0950
37-967	A1	.0300	.0290	.0010
	B1	.0300	.0290	.0010
	C1	.0300	.0290	.0010

TABLE 3 (cont) - CHLORIDE CONTENT BY MASS OF CONCRETE

D - Solid Thick Slab Decks - Soffit

Site No.	Sample	% Soluble Cl^- at Level of Steel (50 mm) (A)	% Background Soluble Cl^- (B)	Soluble Cl^- Contamination at Level of Steel (50 mm) (A-B)
10-19	B6	.0320	.0270	.0050
	C5 + C6	.0360	.0270	.0090
18-13	A2 + A3	.0540	.0075	.0465
21-172	A4	.0540	.0100	.0440
	B4	.0140	.0100	.0040
21-191	A4		.0130	
	B4	.0136	.0130	.0060
22-25	A2	.0110	.0020	.0090
	B2	.0080	.0020	.0060
	C3	.0060	.0020	.0040
22-121	B5	.0170	.0090	.0080
	C2 + C3	.0140	.0090	.0050
22-151	A2 + A4	.0145	.0040	.0105
	B1	.0125	.0040	.0085
	C2 + C3	.0130	.0040	.0090
34-32	A5+ A6+ A7	.0575	.0150	.0425
	B3	.0150	.0150	.0000
	C6	.0185	.0150	.0035
37-33	A3	.0435	.0330	.0105
	B2	.0400	.0330	.0070
	C2	.0370	.0330	.0040
37-341	A4	.0155	.0150	.0005
	B3	.0225	.0150	.0075
	C3	.0165	.0150	.0015
37-967	A4	.0300	.0290	.0010
	B2	.0325	.0290	.0035
	C4	.0325	.0290	.0035

TABLE 3 (cont) - CHLORIDE CONTENT BY MASS OF CONCRETE

E - Thick Slabs with Voids - Top

Site No.	Sample	% Soluble Cl^- at Level of Steel (50 mm) (A)	% Background Soluble Cl^- (B)	Soluble Cl^- Contamination at Level of Steel (50 mm) (A-B)
- Round Voids				
18-179	A1	.0935	.0200	.0235
18-193	A1	.0250	.0150	.0100
	B1	.0325	.0150	.0175
	C1	.0165	.0150	.0015
21-338	A1 + A2	.1400	.0030	.1370
	B1 + B2	.1800	.0030	.1770
	C1 + C2	.0950	.0030	.0920
37-964	A1 + A2	.0225	.0225	.0000
	B1 + B2	.0245	.0225	.0020
	C1	.0250	.0225	.0025
- Rectangular Voids				
10-149	A1 + A2	.0720	.0250	.0470
	B1	.0630	.0250	.0380
	C1	.0680	.0250	.0430
36-29	A1	.0820	.0102	.0718
	B1	.0670	.0102	.0668
	C1	.0180	.0102	.0078
37-93	A1	.2640	.0210	.2430
	B1	.1280	.0210	.1070
	C1	.0680	.0210	.0470

TABLE 3 (cont) - CHLORIDE CONTENT BY MASS OF CONCRETE

F - Thick Slabs With Voids - Soffit

Site No.	Sample	% Soluble Cl^- at Level of Steel (50 mm) (A)	% Background Soluble Cl^- (B)	Soluble Cl^- Contamination at Level of Steel (50 mm) (A-B)
- Round Voids				
18-179	A3	.0224	.0200	.0024
18-193	A4	.0205	.0150	.0055
	B3 + B4	.0185	.0150	.0035
	C2	.0180	.0150	.0030
21-338	A3	.0035	.0030	.0005
	B3	.0035	.0030	.0005
	C4	.0075	.0030	.0045
37-964	B3	.0430	.0225	.0205
	C3	.0660	.0225	.0435
- Rectangular Voids				
10-149	A3	.0255	.0250	.0005
	B2	.0335	.0250	.0085
	C3	.0320	.0250	.0070
36-29	A2	.0102	.0102	.0000
	B4 + B5	.0136	.0102	.0034
	C3	.0150	.0102	.0048
37-93	A1	.0300	.0210	.0090
	B1	.0255	.0210	.0045
	C1	.0275	.0210	.0065

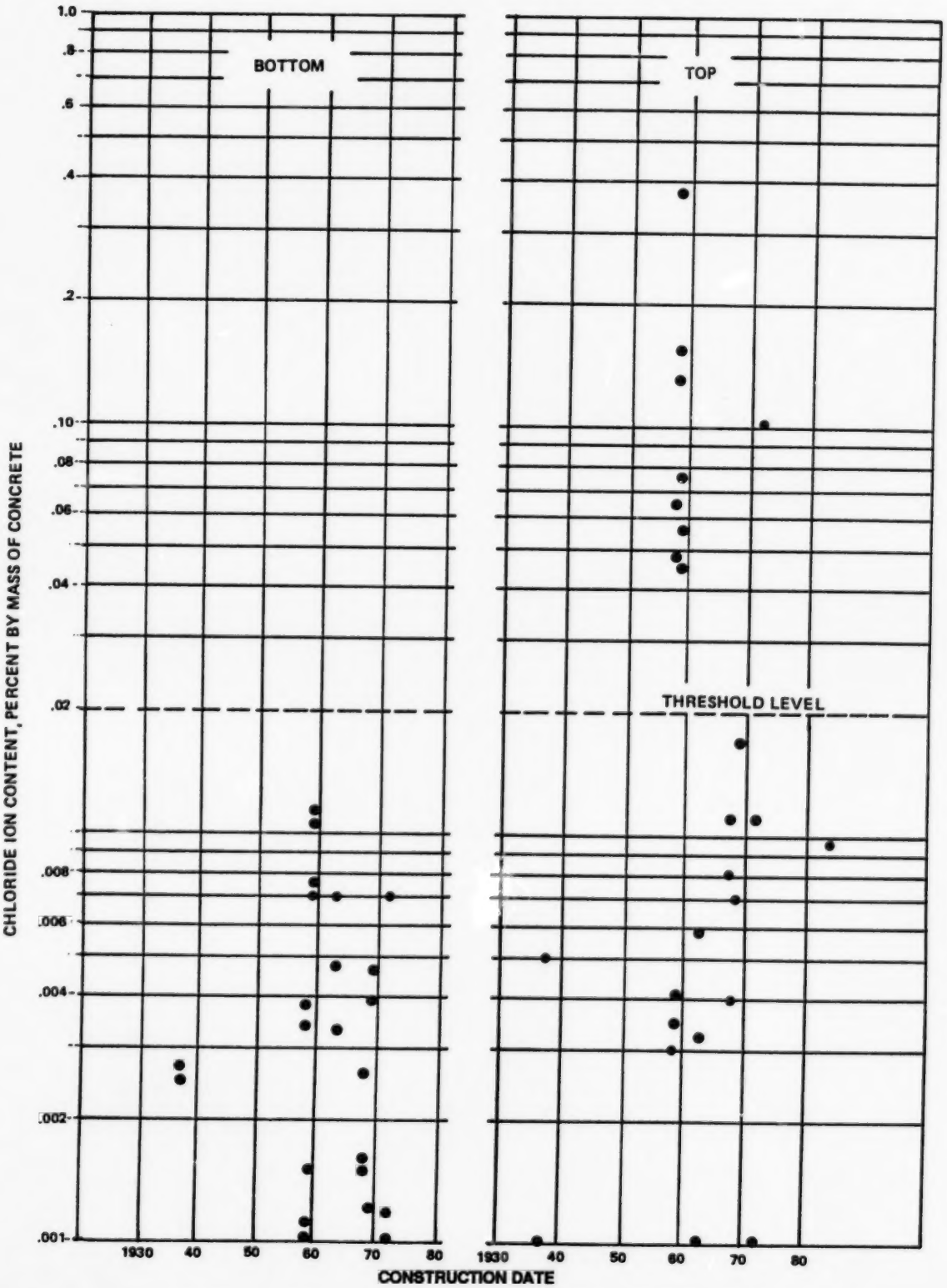


Figure 1 (a)/ Thin Slabs --- Chloride Contamination vs. Construction Date

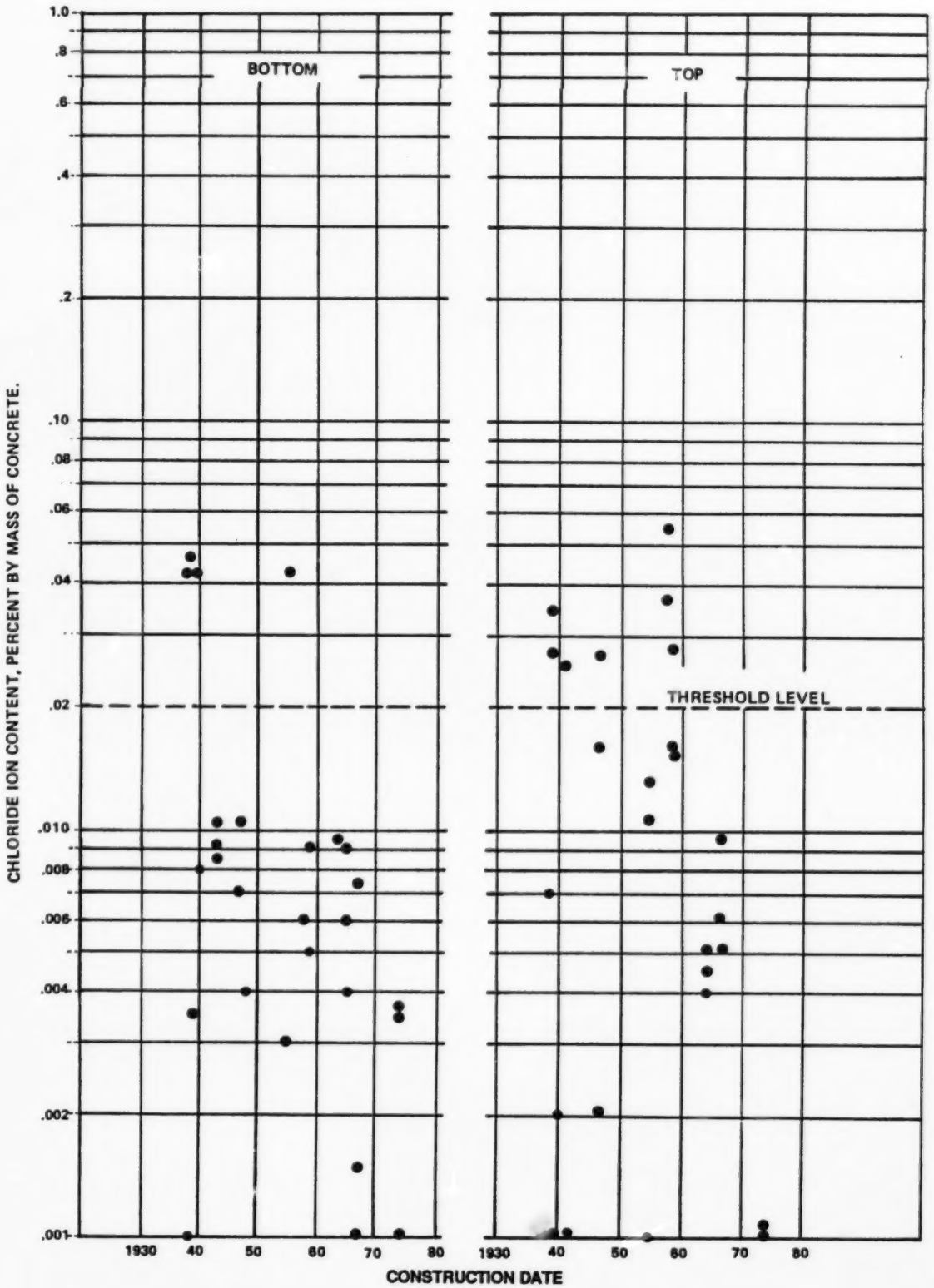


Figure 1 (b)/ Solid Thick Slabs --- Chloride Contamination vs. Construction Date

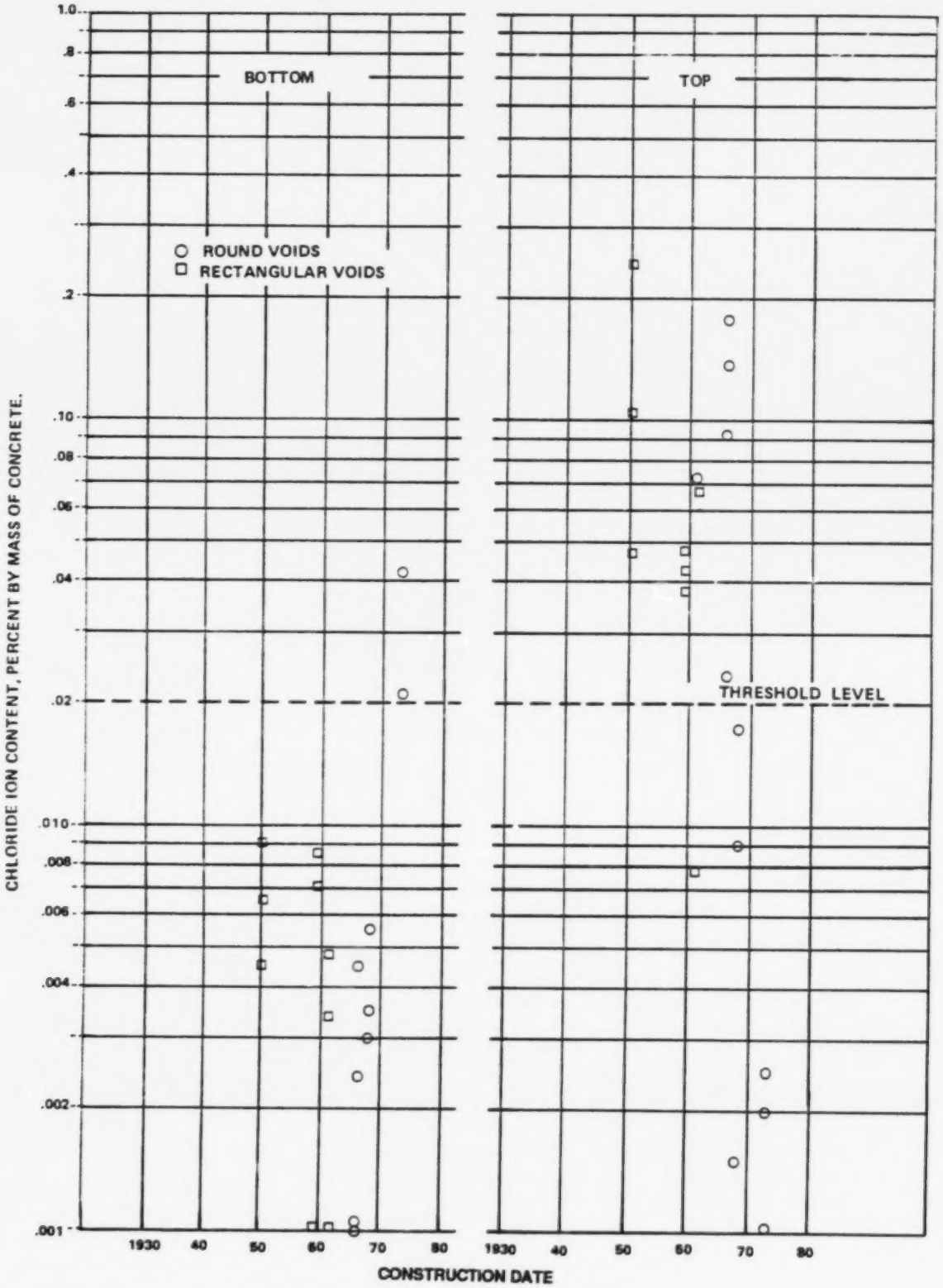


Figure 1 (c)/ Thick Slabs with Voids --- Chloride Contamination vs. Construction Date

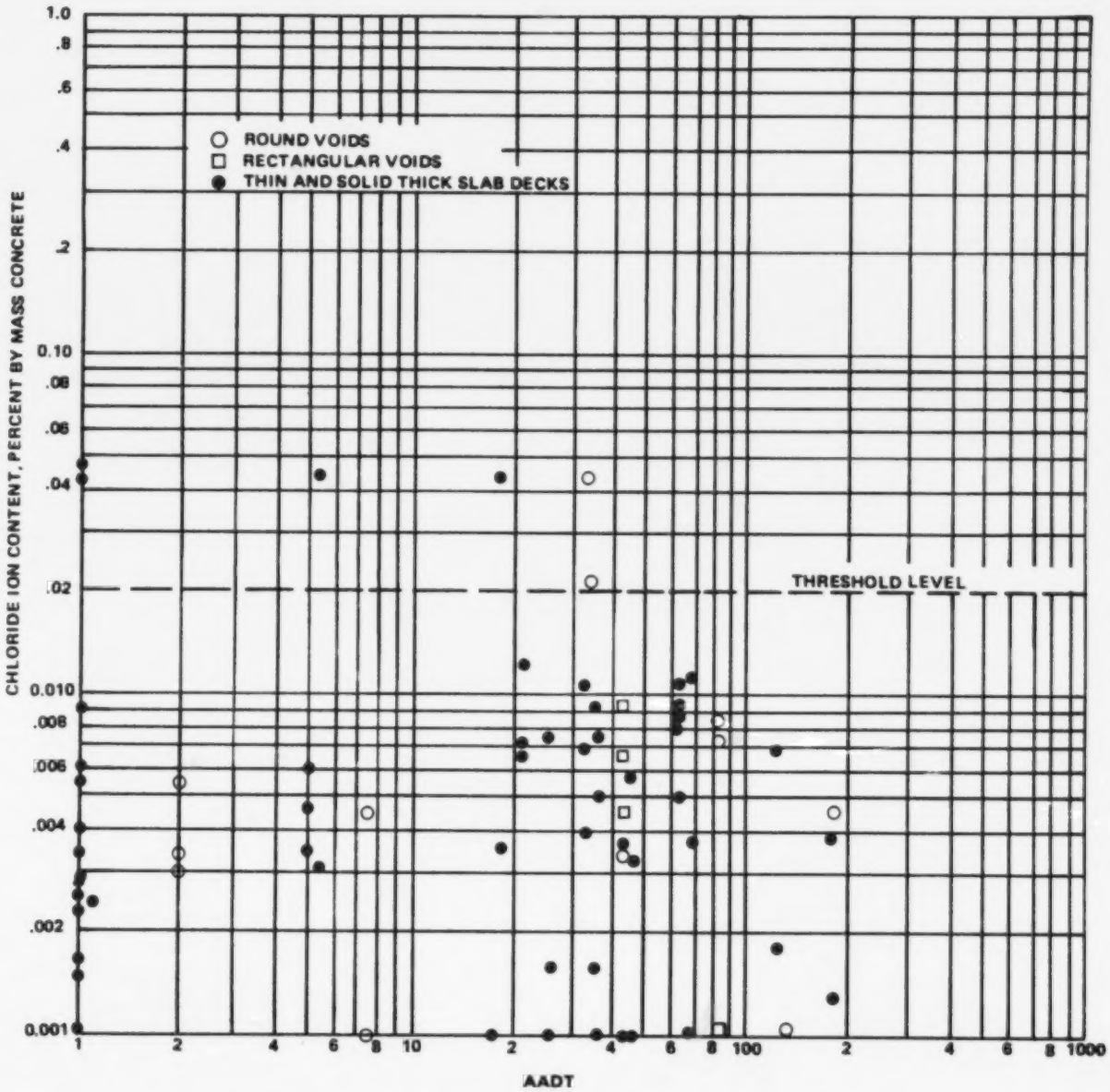


Figure 2 (a)/ Deck Soffits – Chloride Contamination vs. Traffic Volume

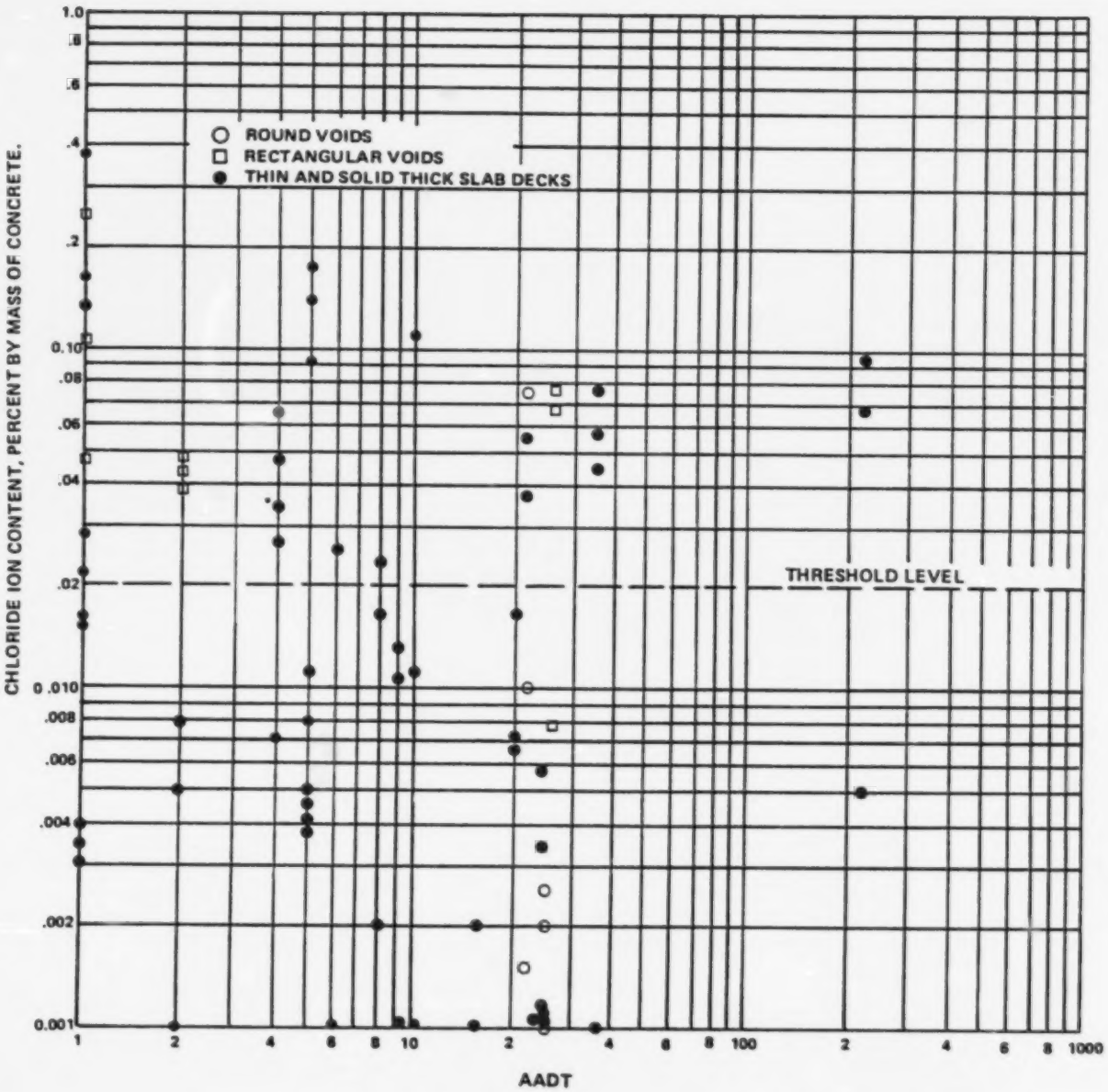


Figure 2 (b)/ Deck Tops — Chloride Contamination vs. Traffic Volume

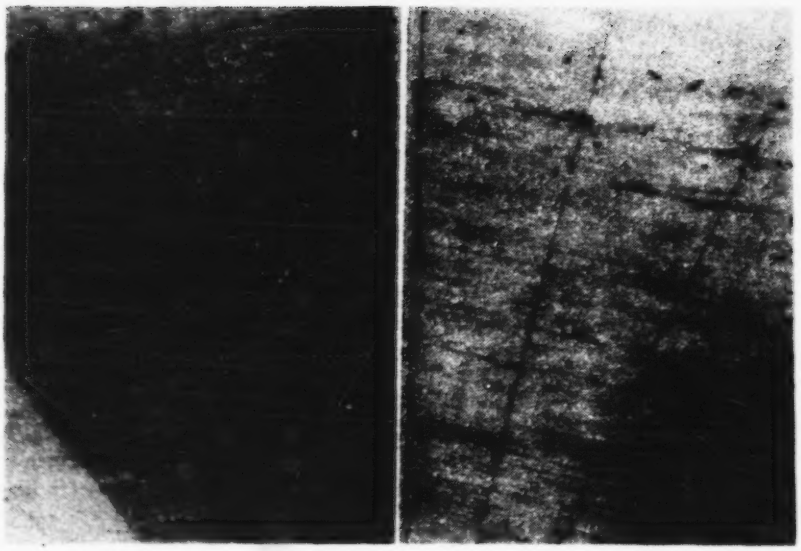
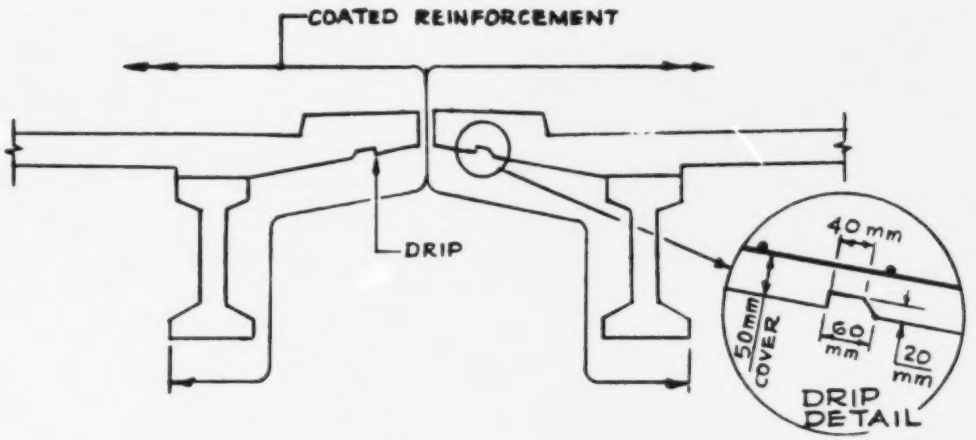
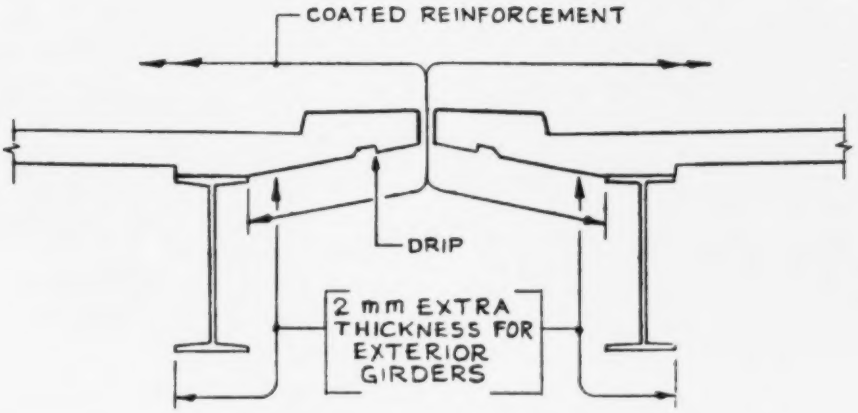


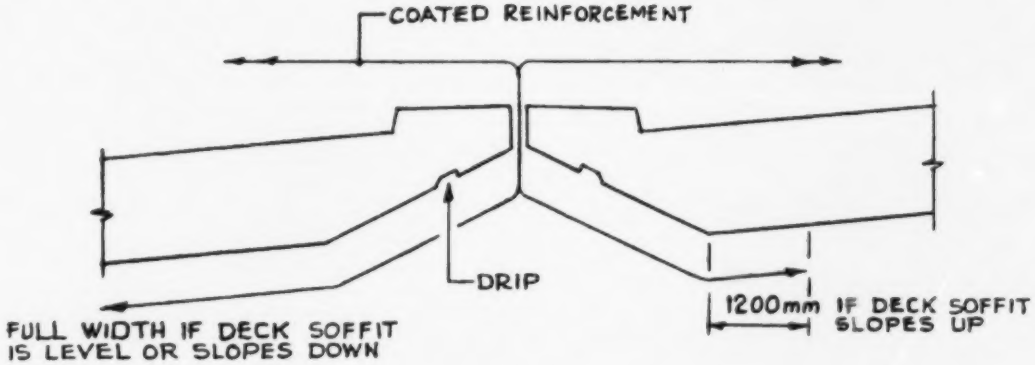
Figure 3/ Site 37-964, Martingrove Road Underpass, Hwy 409



I CONCRETE GIRDERS AND SLAB DECKS

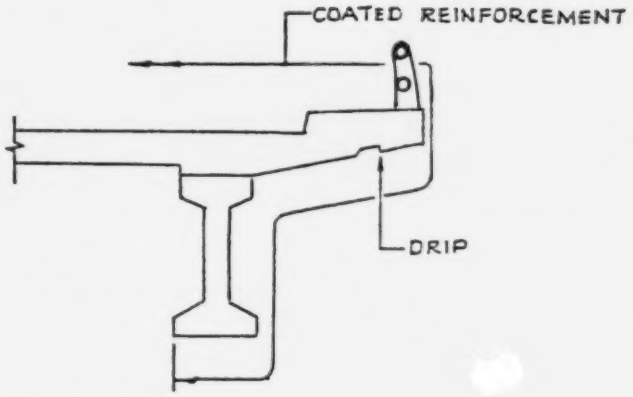


II STEEL GIRDERS AND SLAB DECKS

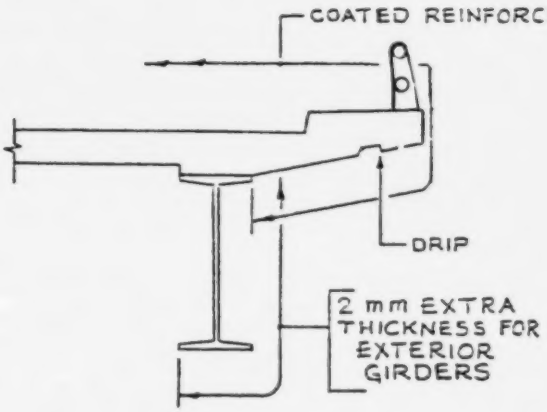


III THICK SLABS WITH OR WITHOUT VOIDS

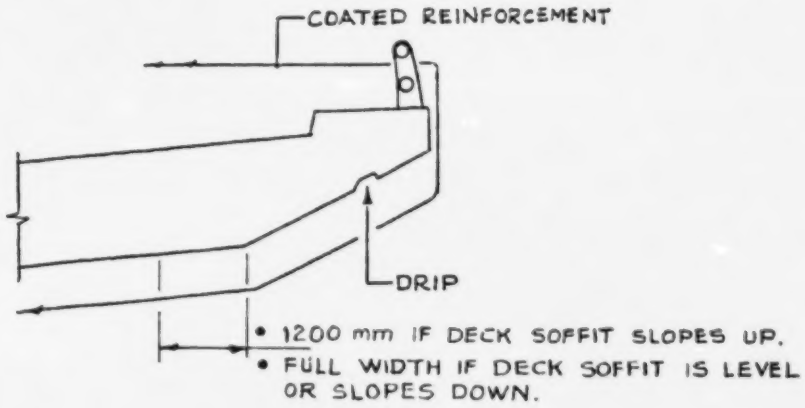
Figure 4/ Coated Reinforcement below Sealed or Unsealed Longitudinal Joints



I CONCRETE GIRDERS AND SLAB DECKS



II STEEL GIRDERS AND SLAB DECKS



III THICK SLABS WITH OR WITHOUT VOIDS

Figure 5/ Coated Reinforcement below Open Type Railings

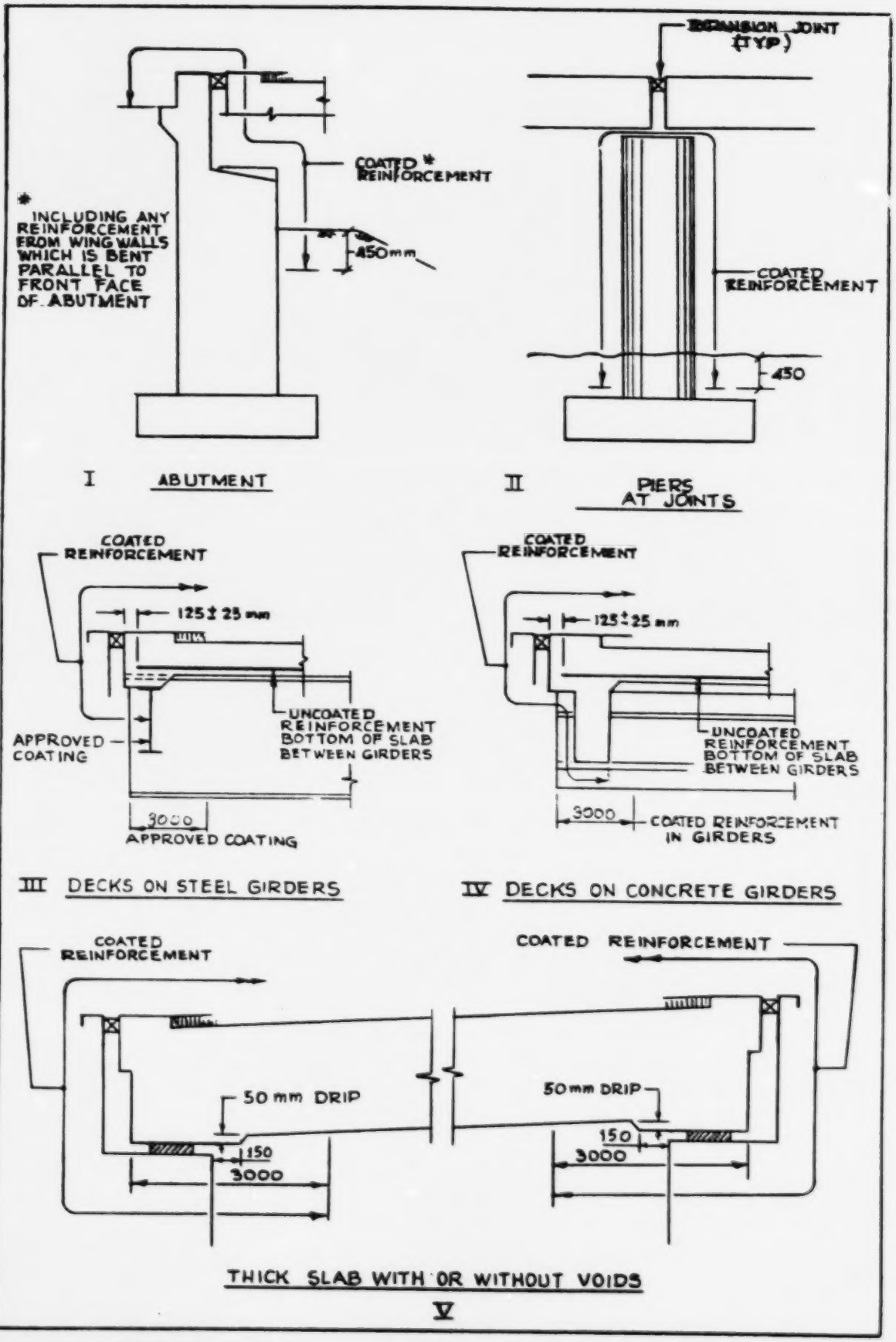


Figure 6/ Coated Reinforcement below Sealed or Unsealed Transverse Joints